SKELETON LAKE

Alberta

ENVIRONMENT
Water Quality Control Branch
Pollution Control Division

89-06094/

Lakes attract people. And people want to know why "their" lake is the way it is — why is it so green in July? Is the water quality really deteriorating? How do our activities affect the lake?

This brochure, one of a series on Alberta's lakes, attempts to answer these questions by presenting findings of water quality studies conducted by the Water Quality Control Branch of Alberta Environment.

As you read through the brochure, you may find you have questions about the concepts and illustrations. At the end is a section called **Explanation of Lake Characteristics.** Refer to this for further interpretation.

Brochures are available for the following lakes:

Sandy Lake	Pine Lake	Lac La Biche
Lac La Nonne	Garner Lake	Nakamun Lake
Wizard Lake	Skeleton Lake	Wabamun Lake

JANUARY, 1985

Skeleton Lake is an attractive, popular lake located about 5 km northeast of Boyle, in Alberta's Lakeland. The lake is heavily developed for its size, with nearly 400 cottages, a boy scout camp, and a commercial resort on the east side of the main basin. There is boat access at the resort.

Skeleton Lake is divided into two basins. The deep north basin is separated from the main basin by a shallow, weedy "narrows". During very dry periods this area has nearly dried up, separating the two basins. The lake's deepest point, in the center of the north basin, is about 17 m (56 ft). The main basin has a maximum depth of about 11 m (36 ft).

The lake's outlet creek flows toward Amisk Lake to the east, although it is often blocked by beavers. The withdrawal of water for Boyle's municipal supply provides another outlet.

Fishing is often good in Skeleton Lake. Northern Pike (jackfish), Yellow Perch, Walleye (pickerel), and Whitefish inhabit the lake. There is usually a commercial fishing season of about one week per year on Skeleton.

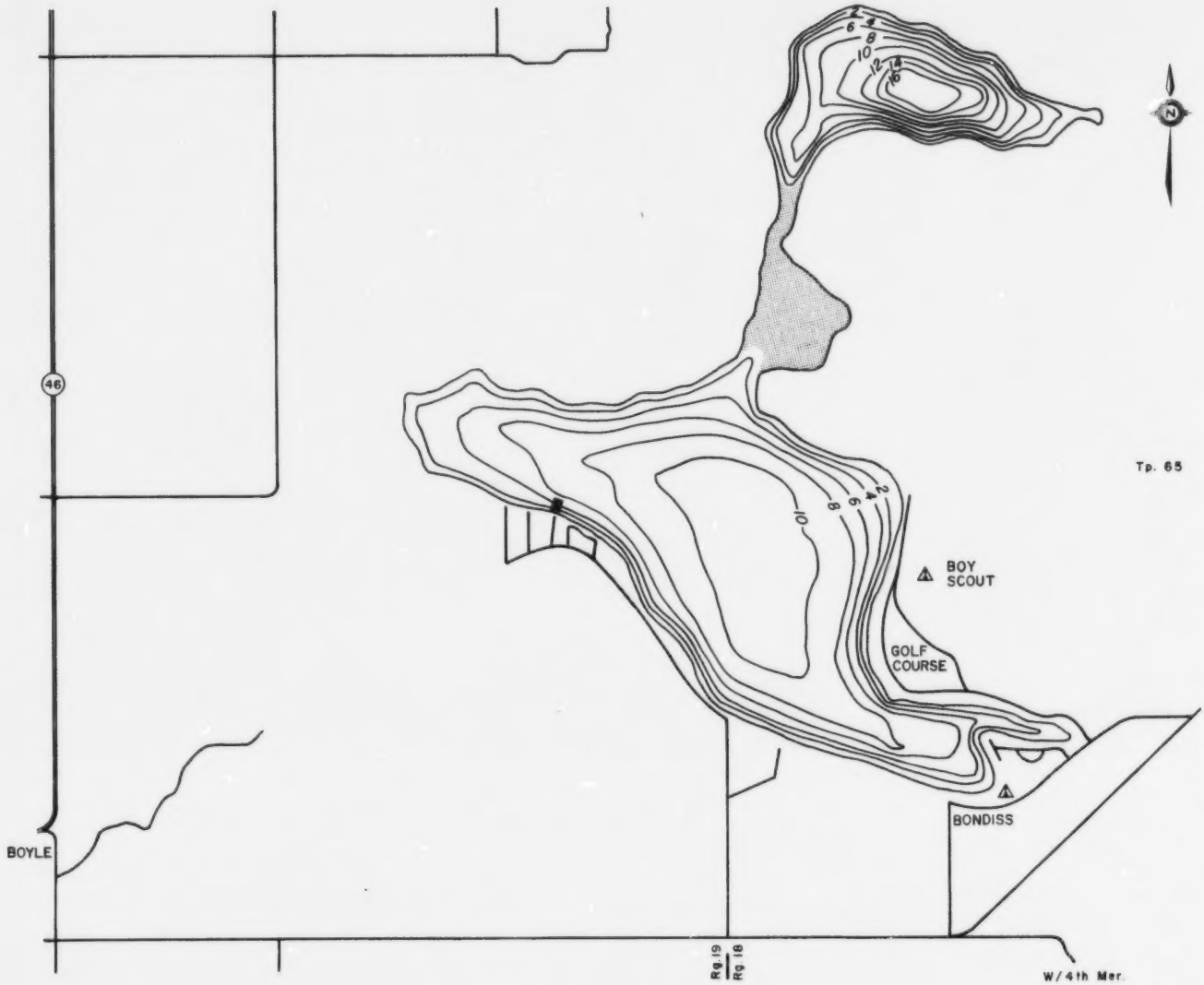
Skeleton Lake's drainage area is fairly small compared with its volume of water. This small ratio (see Physical and Hydrological Characteristics) if considered alone, suggests that the lake should have quite good water quality since there is only a small area of land contributing nutrients.

However, cottage and agricultural development is extensive around Skeleton Lake and because of this the movement of nutrients toward the lake is higher.

The Theoretical Phosphorous Supply table lists the amounts of nutrients estimated to come from each source. If all of the land now developed could be returned to forest or natural vegetation, the supply of phosphorus would be reduced by one-half. This is because cleared land can contribute five times more phosphorus than an equal area of forested land.

The figure for sewage input of phosphorus seems very high. But this is the "worst case" situation. It assumes that everyone's sewage enters the lake — which is certainly not the case. This assumption is made because it is not possible to measure the actual leakage of sewage from septic fields and pit toilets.

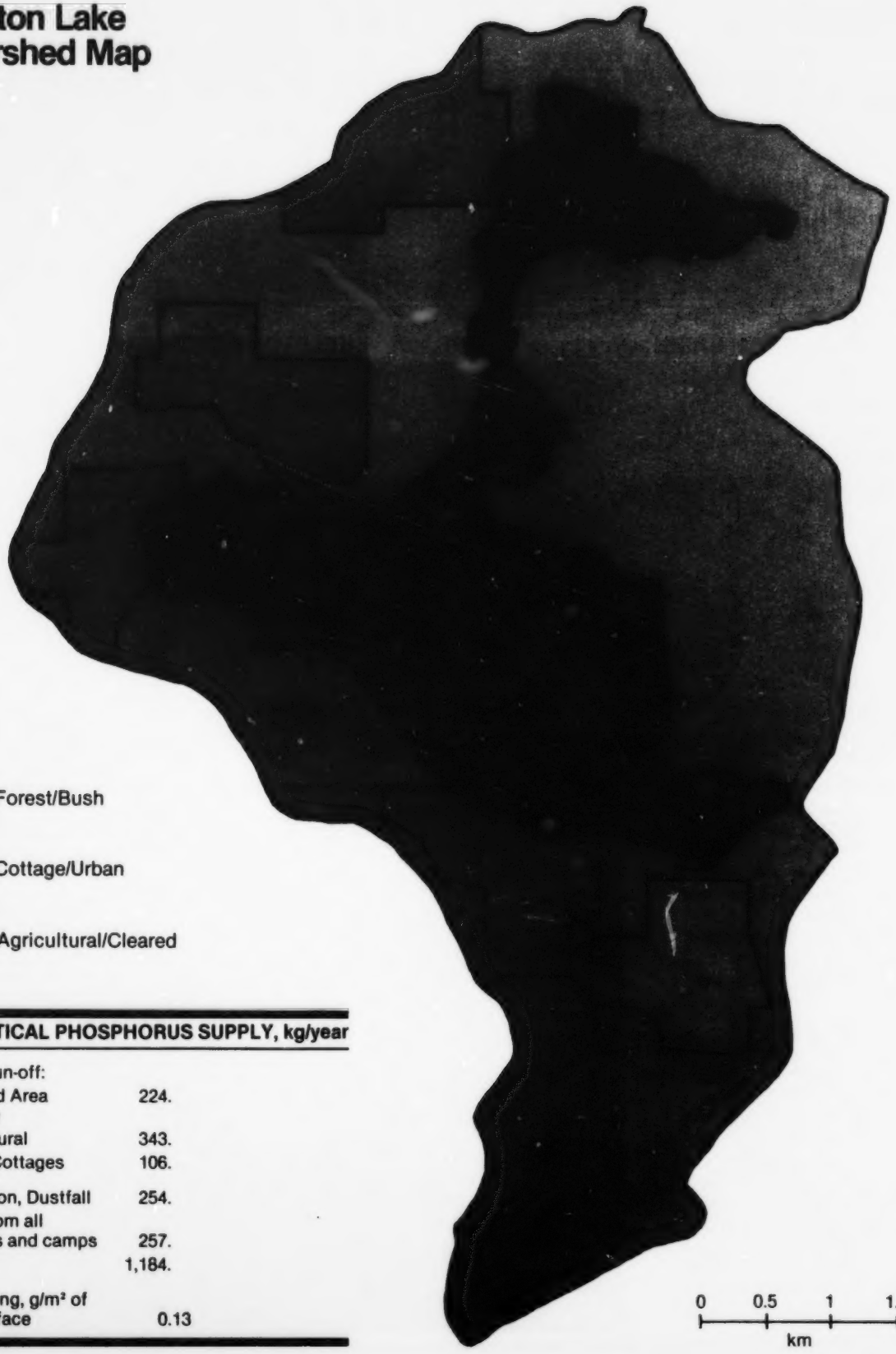
Depth Contour Map



PHYSICAL AND HYDROLOGICAL CHARACTERISTICS

LAKE AREA	km^2	8.78
DRAINAGE AREA (excluding lake)	km^2	31.36
DRAINAGE AREA/ LAKE VOLUME		0.5
VOLUME	m^3	57.8×10^6
MAXIMUM DEPTH	m	17.
MEAN DEPTH	m	6.58
INFLOW	m^3	6.05×10^6
RESIDENCE TIME	years	9.6

Skeleton Lake Watershed Map



Forest/Bush

Cottage/Urban

Agricultural/Cleared

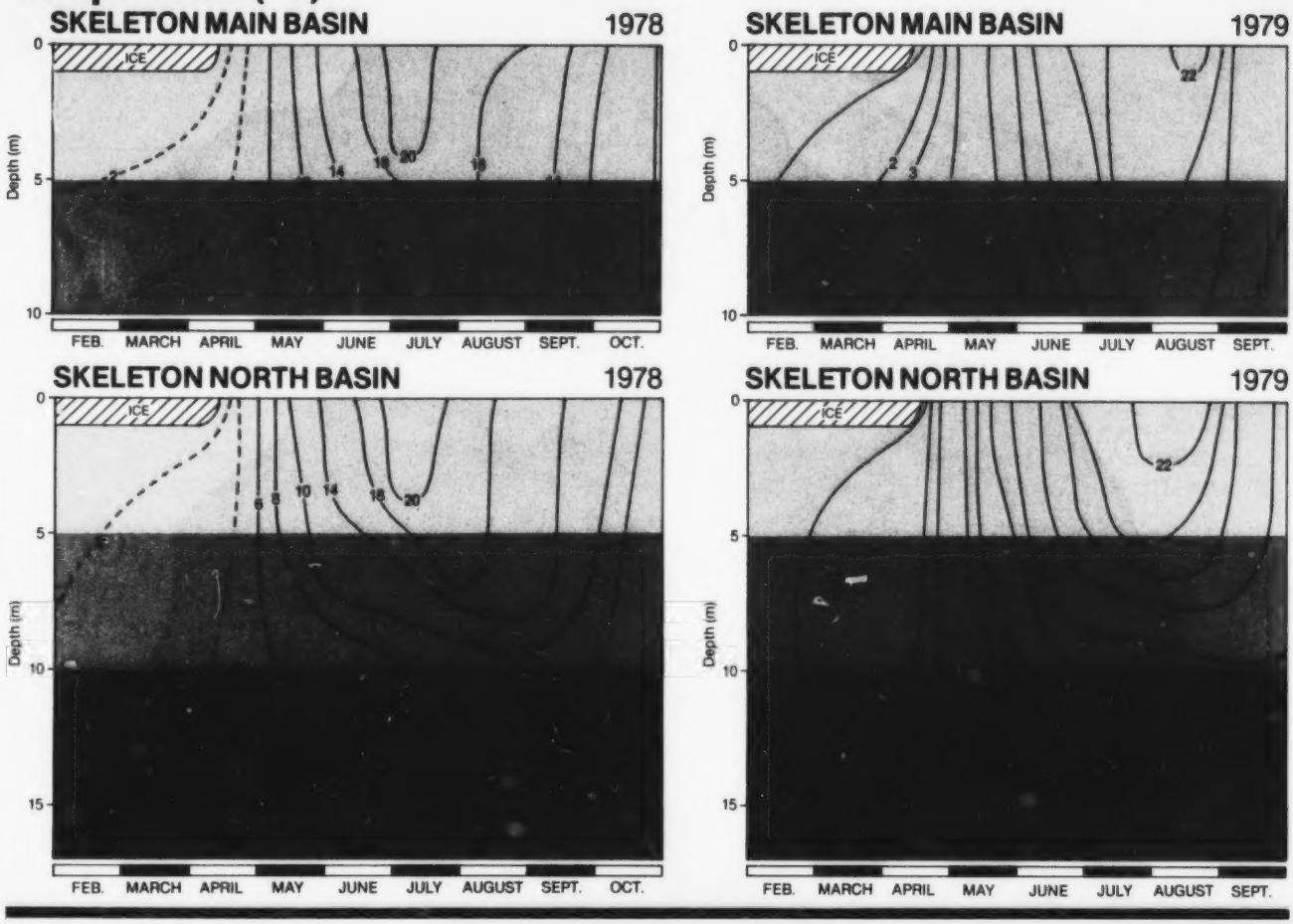
THEORETICAL PHOSPHORUS SUPPLY, kg/year

Surface Run-off:	
Forested Area	224.
Cleared/ Agricultural	343.
Urban, Cottages	106.
Precipitation, Dustfall	254.
Sewage from all cottages and camps	257.
TOTAL	1,184.
Areal loading, g/m² of lake surface	0.13

0 0.5 1 1.5

km

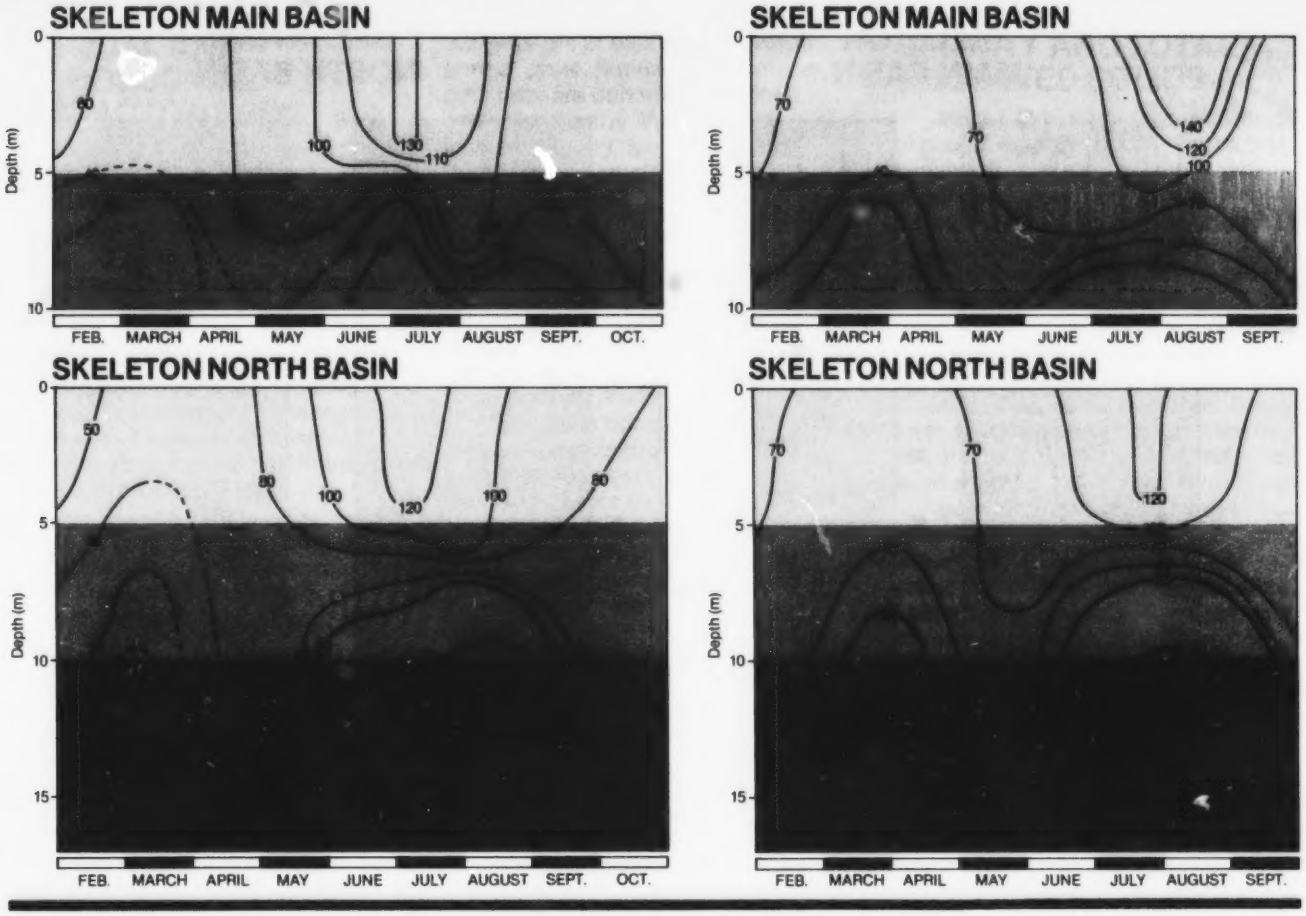
Temperature (°C)



The two basins of Skeleton Lake show different temperature patterns. For both years under study, the main basin was well mixed for much of the period when the lake was free of ice. This is shown on the graph by vertical lines. The looped lines in midsummer indicate that as the surface of the lake warmed quickly on hot days, the lower water remained cool. But this layering would probably be disrupted during strong winds.

The north basin, because it is deeper and more protected, shows strong layering throughout the summer, which wind would not disrupt. The bottom water remained at a maximum of 7 °C even when the upper water was 22 °C.

Dissolved Oxygen (% Saturation)

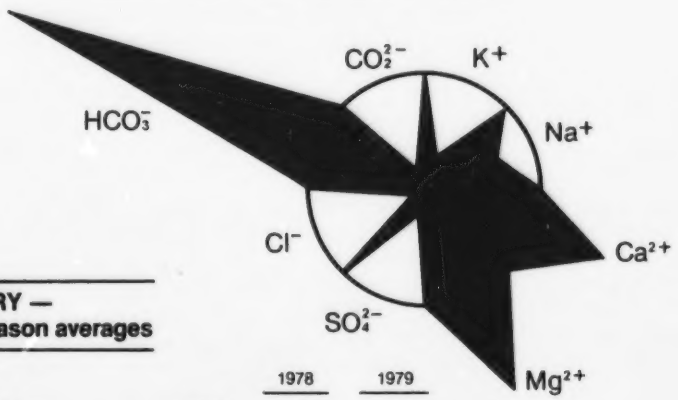


Dissolved oxygen was used up in the bottom water in both basins, so that by June of 1978 and 1979 there was not enough oxygen in the water to support fish below a depth of 8 m. However, the water was supersaturated with oxygen in the upper water in response to algal photosynthesis.

Measurements in the winter showed sufficient oxygen for fish, so that winter fish kills are unlikely in Skeleton.

The ionic diagram shows that the water chemistry of Skeleton Lake is dominated by ions of bicarbonate (HCO_3), magnesium (Mg) and calcium (Ca). This is typical for many Alberta lakes. Skeleton is relatively low in total dissolved solids and alkalinity. All these constituents are well within the range of requirements of fish and other aquatic life.

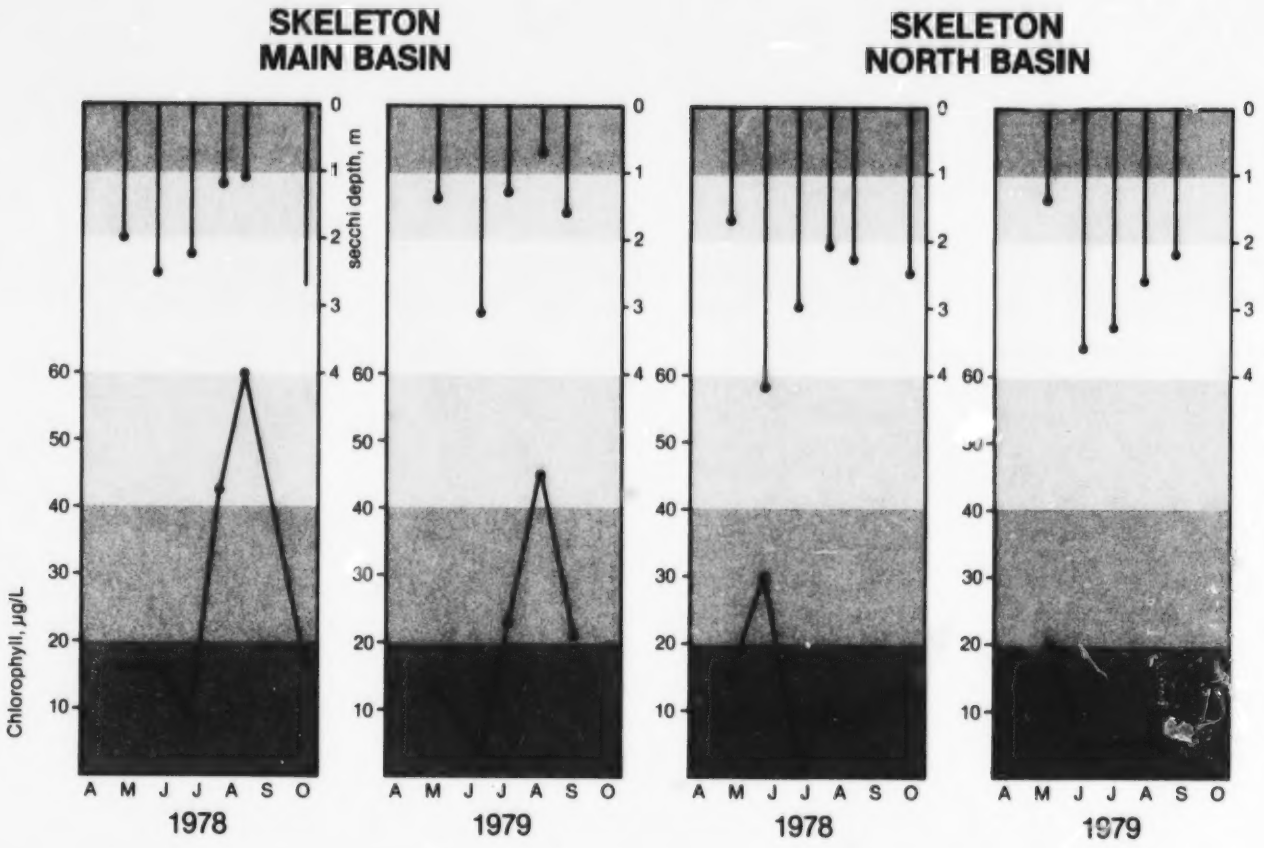
IONIC DIAGRAM — Relative proportions of ions 1977-79



CHEMISTRY — ice-free season averages

		1978	1979
TOTAL SALINITY	meq/l	8.	8.
pH (Range)		7.5 - 8.8	7.4 - 8.8
ALKALINITY	mg/L	175.	183.
TOTAL DISSOLVED SOLIDS	mg/L	185.	193.

Trophic Status



Anyone who has spent time on Skeleton knows that the north basin is often very clear when the main basin is green with algae. There seems to be two reasons for this. The watershed area which supplies nutrients to the north basin is relatively smaller and more forested than that supplying nutrients to the main basin. Additionally, the shallow main basin is mixed, so that water lying over the bottom mud can circulate to the upper water. Nutrients concentrated in the mud move into the water when oxygen is low, so that nutrient supplies to growing algae are continually replenished. In the north basin, these nutrients are trapped in the bottom layer until the lake mixes in October.

As the Trophic Characteristics table shows, the north basin of Skeleton Lake had half as much chlorophyll (algae), less phosphorus and generally clearer water than had the main basin. The pattern of chlorophyll over the summer was different in the two basins. The main basin showed a pattern that is typical for most shallow fertile lakes: the greatest amount of algae occurred in late summer. In the north basin, the peaks occurred in May-June and in the fall, showing the effect that layering has on trapping nutrients.

The graphs above show that the quantity of algae was less in 1979 than in 1978. This is probably related to weather conditions, since several lakes in central Alberta showed similar patterns. Skeleton Lake may be considered eutrophic, although the north basin borders on mesotrophy (see Explanation of Lake Characteristics).

TROPHIC CHARACTERISTICS — ice-free season averages

		MAIN BASIN		NORTH BASIN	
		1978	1979	1978	1979
PHOSPHORUS	µg/L	50.0	42.9	50.0	34.3
NITROGEN	mg/L	1.55	1.38	1.58	1.41
CHLOROPHYLL	µg/L	27.0	14.63	12.9	7.31
SECCHI TRANSPARENCY	m	2.0	1.6	2.7	2.6

Explanation of Lake Characteristics

PHYSICAL AND HYDROLOGICAL CHARACTERISTICS

Drainage Area or the watershed of a lake is the land surface from which a lake receives its water. As rain water or snowmelt gathers in streams, it picks up soil particles, nutrients and other materials and carries them to the lake.

A study of more than 30 Alberta lakes shows that when drainage areas are large compared to lake volumes, (i.e. when this **Drainage Area/Lake Volume** ratio is large), lakes have more algae (are more eutrophic) (see TROPHIC CHARACTERISTICS).

Mean Depth is the volume of the lake divided by the surface area. Shallow lakes are often more eutrophic than deeper lakes of a similar size.

Inflow is the total volume of water entering the lake in a year. It is related to **Residence Time,** which indicates the time it would take the inflow to completely fill an empty lake.

TEMPERATURE

Alberta lakes show two basic annual patterns of temperature distribution through the water.

Deep lakes, or those protected from strong winds, form layers with the coldest water near the bottom. Because this colder water is denser, it resists mixing into the warmer, lighter upper layer.

For much of the summer, the bottom portion of water is isolated from the top portion. In spring and fall, these lakes usually mix from top to bottom from wind action as the water becomes uniform in temperature and density. In winter, under ice, the warmest water (about 4 °) is on the bottom, because water is most dense at this temperature.

Shallow lakes mix throughout the summer or layer only temporarily. In winter, the temperature pattern of these lakes is similar to that of deep lakes.

The diagram(s) show temperature at each depth over the annual cycle. Similar temperatures over time are connected by lines called isotherms. Vertical lines indicate mixing, while horizontal lines indicate layering.

DISSOLVED OXYGEN

Oxygen is essential to the life in lakes. It enters the lake water from the air through wind action, and plant photosynthesis.

Oxygen is consumed by respiration of animals and plants, including the decomposition of dead organisms by bacteria. A great deal can be learned about the "health" of a lake by studying its patterns and quantity of oxygen.

Lakes that are unproductive (oligotrophic) will have sufficient oxygen throughout the year at all depths. But as a lake becomes more eutrophic, and increasing quantities of plants and animals respire and decay, the balance shifts toward consumption — especially near the lake bottom where dead organisms accumulate.

In deep productive lakes (see TEMPERATURE), the oxygen in the isolated bottom layer may deplete rapidly, forcing fish to move into the upper layer (Fish are stressed when oxygen falls below about 20% saturation — shown in red on the diagram). Fish kills occur when decomposing or respiring algal populations use up the oxygen. In summer, this usually happens during an algal bloom on calm nights.

The diagram shows oxygen saturation at each depth over the annual cycle. Similar saturations over time are connected by lines called isopleths. Vertical lines indicate uniform saturation from top to bottom, while horizontal lines indicate stagnation near the bottom.

SALINITY AND TOTAL DISSOLVED SOLIDS

Lake water contains a multitude of dissolved substances. These can be seen by allowing a dish of lake water to evaporate. If the water is filtered to remove living organisms and other particles, and then allowed to evaporate, the residue is called **Total Dissolved Solids.**

The ions* that make up most of this residue can be measured individually, giving a value for **Total Salinity** when added together. The **Ionic Diagram** presents all of the major ions in a lake in proportion to each other.

Salinity is controlled by the types of rock or soil in the watershed and by the amount of evaporation relative to precipitation. Lakes of high salinity, such as many of those found in southeastern Alberta, have fewer species of plants and animals than freshwater lakes; many are too saline to support fish.

*Ions: Chemical form in water of constituents such as sodium and carbonate.

PH AND ALKALINITY

The pH of lake water refers to its concentration of hydrogen ions on a scale that runs from 0 (extremely acidic) to 14 (extremely alkaline). A pH of 7 is neutral — neither acidic nor alkaline.

Most Alberta lakes fall between pH 6 to 9, with the majority on the alkaline side. **Alkalinity** refers to the capacity of water to neutralize an acid, and is a measure of the alkaline materials present in the water.

Alberta lakes that were formed in sedimentary bedrock have a large capacity to neutralize acids entering them, such as from acid rain.

TROPHIC CHARACTERISTICS

The word "trophic" literally means nourishment.

Mountain lakes usually are "poorly nourished" or **oligotrophic.** Levels of nutrients such as phosphorus and nitrogen are low, plant life is sparse, and the water is clear. Fish production is low.

On the other end of the scale are well-nourished or fertile lakes called **eutrophic.** In these lakes, aquatic plants, including tiny suspended algae, flourish because the water contains abundant nutrients.

Mesotrophic lakes, those intermediate in fertility, often combine the best features of the other two types.

In some lakes, the nutrient supply is so high that plant growth inhibits the recreational use of the lake. Lake users consider such a lake to have poor water quality. One of the purposes in studying lakes is to determine whether fertility is increasing.

There are several ways to measure a lake's fertility or **Trophic Status.**

Phosphorus and **nitrogen** can be measured directly. Phosphorus in lakes of the Boreal Forest/ Parkland areas of Alberta range between 10 and 120 ug/L, or oligotrophic to highly eutrophic, and nitrogen ranges between 0.5 and 3.5 mg/L.

Transparency declines as a lake becomes more fertile. It is measured with a black and white plate called a **Secchi Disc,** which is lowered through the water on a line marked at metre intervals. The depth at which it can no longer be seen is the Secchi transparency.

The quantity of algae in the water can be determined by measuring its content of **Chlorophyll,** the green photosynthetic pigment.

The number of animals living in the bottom mud of the lake also may indicate its fertility. **Oligochaeta** are tiny worms; **Chironomidae** are immature stages of a fly called a midge.

THEORETICAL PHOSPHORUS SUPPLY

Lake scientists know that for most lakes, the amount of algae in the water is related directly to the amount of phosphorus. This is because phosphorus is usually in shortest supply of all the nutrients that lake plants need. When it runs out, the algal population can no longer increase. A larger phosphorus supply usually results in more algae.

Based on studies from all over North American, the quantity of phosphorus contributed by a hectare of forest is remarkably similar no matter where the lake is located. Similarly, agricultural or cleared land overlying sedimentary bedrock contributes fairly similar quantities of phosphorus per hectare in most lake watersheds. This was confirmed for Alberta by measuring quantities of phosphorus supplied by various land uses in the Baptiste Lake watershed.

In all studies, the phosphorus supply from cleared or agricultural land was greater than that from forest, averaging 5 times more.

The "theoretical" phosphorus supply is estimated, without actually measuring it, by multiplying phosphorus supply factors for each type of land use by the area of that land use.

Similar factors are used for the supply from precipitation. The supply from sewage assumes that all sewage enters the lake, since it is nearly impossible to measure this source in lakes. Therefore, the number reported represents the maximum possible supply from that source.

It might be expected that a large phosphorus supply would produce a eutrophic lake. But the size of the lake is also important. If the total phosphorus supply is divided by the surface area of the lake, the resulting **Areal Loading** figure can be compared with other lakes, and can be used as an indication of trophic status.